

## **SECTION 7**

### **EXAMPLE OF SYSTEMS CONTROL THROUGH INSTRUMENTATION**

#### **CONTENTS**

	<b>Page</b>
7.1 General . . . . .	123
7.2 Description of Project Problem . . . . .	123
7.3 Project Requirements . . . . .	124
7.4 Comments . . . . .	132

## 7.1 General

The following example of total system control of a hypothetical combined sewer system through the use of instrumentation, automation, and data control devices, has been developed to provide a practical demonstration of the application methodology required for its implementation. The intent of the section is to examine how an effective control system may be developed.

## 7.2 Description of Project Problem

### CENTROPOLIS

### PROJECT NO. 5468

### CONTRACT 13

### REGULATING STATION NO. 5

*General* This will be located near Eight-Mile creek at approximately Station 28+00 on the Eight-Mile interceptor just west of the west right-of-way line of Highway 6 out of Worden. Ground elevation is approximately 885. The City has entered into a contract with the adjacent Minneola Sanitary District to divert part of the combined sewage from this interceptor to a new system which will allow the postponement of treatment plant expansion for several years. The structure will be similar in appearance to Station No. 2 for Appenouse which was completed this spring. A downstream regulated weir will be part of another contract.

*Head Conditions* Maximum hydraulic gradient at the regulating station influent will be EL. 870. Minimum gradient is assumed to be EL. 845. Minimum gradient of the connection to the Minneola interceptor will be EL. 820 and maximum gradient may approach EL. 862.

*Flow Limitations* The present contract limits the maximum rate of diversion under any condition to 500 gpm. In addition, the maximum rate of diversion from 3:00 p.m. to 9:00 p.m. on any day when the temperature is 90°F or higher is limited to the average hourly diversion rate during the 24 hour period ending at 9:00 a.m. on such date.

*Equipment* The station will contain the following major items of equipment:

1. One throttling gate. This gate normally shall remain fully open for gravity flows up to the amounts limited by the contract. For higher flows the gate shall then be automatically throttled to maintain the flow within the contracted amounts.

2. One mechanically operated check gate to automatically prevent backflow through the check gate. This will require no control or electric equipment.

3. Two 125-horsepower variable speed pumping units, each sized to deliver up to the contracted maximum quantity under any imposed head condition. Either pumping unit may be selected as the lead pump with the other serving automatically as a standby pump if the lead pump fails. Pumps shall always start at a minimum speed.

4. Each variable speed pump will have a discharge valve of a particularly low allowable working pressure. It will, therefore, be necessary to design the control to prevent a differential pressure across the valve in excess of 10 psi.

5. Influent level shall be measured at Station 43+00, approximately 7500 feet upstream from the diversion regulating station. Control shall be such that at a certain adjustable low level the regulating station will shut down to prevent any diversion from the Eight-Mile interceptor.

6. The regulation station effluent flow shall be metered and used for feed-back to the control. The control and instrument designer shall investigate and determine the type of metering. The effluent conduit will be 36-inch concrete pipe.

7. The Minneola Sewer District plant influent screen chamber wet well level shall be measured and telemetered to the regulating station. At an adjustable plant influent high level, the regulating station shall be shut down.

8. Provision shall be made for two incoming 480-volt, 3-phase, 60-hp. services. Only one service is to be installed originally with space for the second service in the future.

9. Gate and valve operators shall be electric or pneumatic with independent opening and closing speed adjustments.

10. Pumps, motors and controls shall be housed indoors, separated from sewers. The building shall be force-ventilated.

*Sequence Of Operation* The station controls shall be such that the flow diverted from the Centropolis Eight-Mile interceptor will be maintained at a set-point rate, adjustable between 200 gpm and 1200 gpm. The sequence should be such that first the

throttling gate opens slowly when Eight-Mile interceptor reaches Elevation 1.5 at level measuring Station 43+00. If the hydraulic conditions are such that set-point flow can be maintained by gravity, the throttling gate shall be automatically positioned to effectively operate as a rate-controller. As the level rises and set-point is maintained by the gate no pumping is required.

If the hydraulic conditions are such that the throttling gate is open, the level remains above 0.5 feet at the level measuring station, and the diverted flow is less than set-point quantity, the lead pumping unit should start at minimum speed and rise in speed slowly to deliver set-point flow. In this case the pumping unit shall continually vary in speed to effectively operate as a rate-controller. The pumping unit discharge valve should not commence to open, however, until the pump discharge pressure is greater than the station discharge pressure. During the sequence of putting the pumping unit on line, the speed also should be such as to limit the differential pressure across the pump discharge valve to a maximum of 10 psi. It may be decided not to start the lead pump until the level reaches approximately 2.0 feet at Station 43+00. If, due to malfunction, the lead pump should fail to start, the standby pump should be started in a similar pump and discharge valve control sequence whenever the Eight-Mile interceptor level rises to Elevation 2.25. In this case the standby pump is to effectively operate as a rate controller to maintain set-point diversion rate-of-flow. The two pumps shall never operate in parallel.

Pumping, once commenced, shall be maintained until the Eight-Mile interceptor level falls to 1.0 foot, in which case the pump speed shall be reduced to minimum, the discharge valve slowly closed, and finally, the pumping unit stopped.

High water level at the Minneola Sewer District Plant No. 1 shall override all controls and shut down the regulating station by stopping the pumps and closing the throttling gate.

In case of power failure, an over-riding control shall slowly close the throttling gate and pump discharge valves.

Arrangements shall be made for the future monitoring of station equipment status and alarm conditions at the proposed Operations Control Center whenever it is designed.

*Miscellaneous* During the first years of operation it is

anticipated that the required quantity of diverted flow by gravity through the regulating station will sometimes, under certain hydraulic conditions, not be of sufficient quantity to fill the interconnecting conduit during normal contracted flow rate. Therefore the flow meter must not be of a design requiring a filled pipe. Flushing water will not be available for several years.

The final selection of the throttling gate and check gate has not yet been determined.

The plans and specifications must be completed in early June to be eligible for appropriations approved for this project. Plans and specifications are 80 percent complete. Rather than delay the project, certain detailed features of equipment may have to be modified and covered by change order after award of contract.

### 7.3 Project Requirements

This is a common situation. The project must meet a certain deadline. The problem is defined. The solution is somewhat hazy, however, depending upon the ingenuity of the control and instrumentation designer together with those of each of the other disciplines involved.

At this point the designer will begin to conceive the parts and their relationship to the whole. These parts or subsystems will be reduced to functional block diagrams and schematics. These subsystems will then be put into greater systems until all are combined into one system.

It is not feasible or practicable in many cases to wait until all of the necessary details are resolved before proceeding with the scheme of control. In this case, it is recognized that some suitable means for metering flow must be determined, and that this may be a real hurdle but for the purpose of starting the control schematic this is assumed possible and the development of the scheme is taken from the point of a metering signal representing flow. The control designer can make other assumptions too, such as the means of varying the speed of the pumps. In this case it can be assumed that some type of slip coupling can be used for speed regulation; then, if some other means of variable speed drive is selected the control scheme can be modified to conform to that particular drive circuitry.

It may be, as in this case, that the throttling valve and check gate may not be definitely determined as to type, manufacturer, etc.; however, the control designer must assume that such equipment will be

found and that it can be driven by standard type operators. Again, the control designer may have some misgivings regarding the hydraulics, as defined in the memorandum; however, he must proceed upon the assumption that such information is reasonably correct or will be corrected. It also must be assumed that suitable means of communications links, such as leased telephone lines will be made available, the details of which can be ascertained later. All of this is simply to show that the instrumentation and control scheme can be commenced early in design stage, as it certainly should be, since its development points out more clearly all of the special requirements of the system equipment.

The control designer will choose from his past experience whether to use as a basic control media pneumatic, hydraulic, or electric devices, or perhaps a combination of such instruments. In this particular case, he chooses to use both pneumatic and electric systems with some hydraulic devices for timing control.

For those who are interested in examination of yet more detail that must be conceived, an example of the functional block diagrams and schematics for this hypothetical project is shown in the following figures together with a written description of the actual performance of each particular element employed.

The block chart is a typical exercise in the logic that must be conceived and employed in the design development of a control scheme. The diagram is used to describe the instrumentation, whereas schematics are used to describe the electrical circuits. By reference to these diagrams while reading the following steps, one can follow the design logic used. No two designers would necessarily arrive at the same means of solution. For example, whereas this solution has used a considerable number of pneumatic control devices, the problem could be solved using almost all electric and electronic equipment.

It has been assumed that the station would best be designed to function automatically with local controls, then to superimpose the necessary remote control features after this local automatic mode of control is fully explored and developed. This is reasonable since the station must be constructed to be operable locally for such contingencies as loss of remote control facilities, or even to be operated prior to the construction of the Central Operations Center. Details, such as time of day that certain rates might be allowed are also disregarded at this stage of the design, since they too can be assumed to be superimposed on the basic scheme.

The following describes the step-by-step features for both the local-automatic and the local-manual control modes:

#### Automatic Control

1. The Eight-Mile interceptor waste water level, measured over a five-foot control range for control accuracy only regardless of overall depth, is telemetered from the measuring station to a telemetering receiver at the regulating station. The telemetering receiver is equipped with adjustable contacts for control circuit switches, as follows:

EM-1 Normally open contact, closes on rising level at 0.5 feet and remains closed above. This contact prevents pumping when the interceptor level is below 0.5-feet.

EM-2 Normally open contact, closes on rising level at 1.0-foot and remains closed above. This contact prevents pumping when the interceptor level is below 1.0-foot.

EM-3 Normally open contact, closes on rising level at 1.5-feet and remains closed above. This contact prevents the regulating station beginning operation until the interceptor level rises to 1.5-feet.

EM-4 Normally open contact, closes on rising level at 2.0-feet and remains closed above. This contact prevents the beginning of any pumping to commence until the level rises to 2.0-feet.

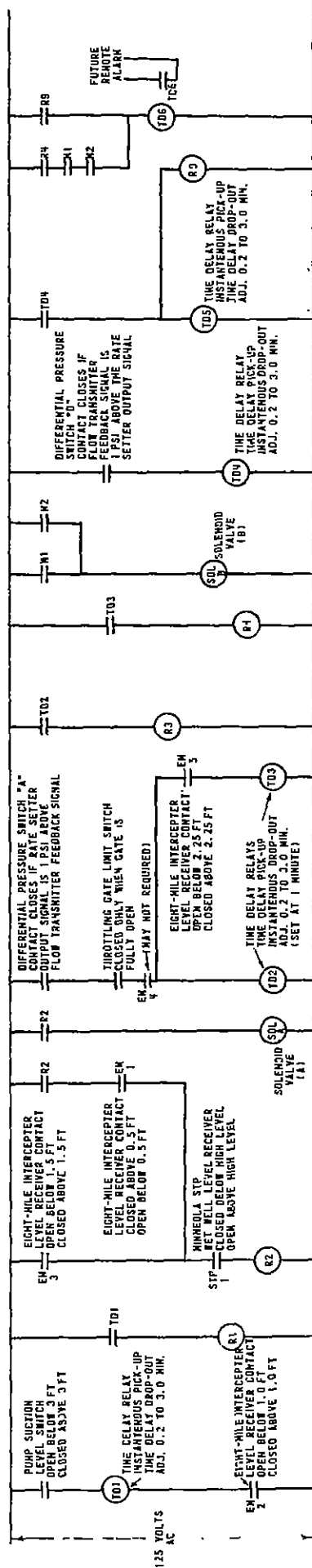
EM-5 Normally open contact, closes on rising level at 2.25-feet and remains closed above. This contact prevents any standby pumping to commence until the level rises to 2.25-feet.

EM-6 Normally closed contact, open on rising level at 0.05-feet and remains open above. This contact can be used for monitoring and alarm of the level measuring equipment by sensing an essentially zero level measurement.

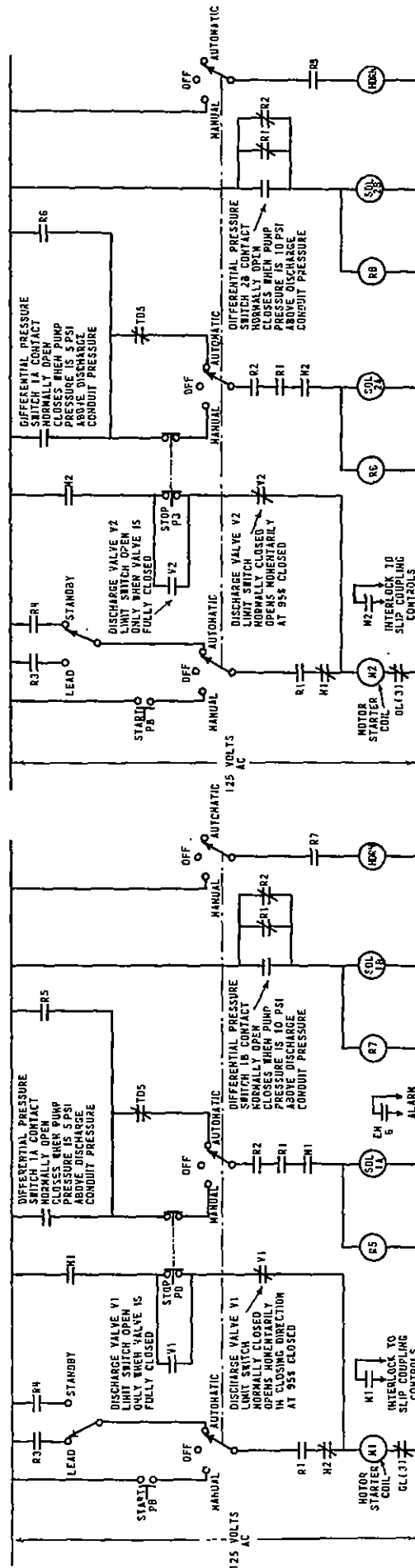
2. The Minneola sewage treatment plant influent wet well level is measured and telemetered to the regulating station. The regulating station is not to operate during the time that this plant is over-loaded. Contacts are therefore provided in the plant level telemetering receiver for use in the control circuits. Only one contact, STP 1, which is normally closed and opens on rising level at some high level setting is required.

3. A rise in waste water level on Eight-Mile interceptor to 1.5-feet closes receiver contact





LONDON CONTROL SCHEMATIC



PUMP NO. 1 MOTOR CONTROL SCHEMATIC

EM-3, which is in series with the Minneola plant level receiver contact STP-1, to complete a control circuit through relay R2 to energize relay R2.

4. When relay R2 is picked up (energized) it seals itself in through one of its own contacts R2 so that it will remain energized until power to the relay is interrupted by either a fall in the interceptor level to 0.5 feet causing the level contact EM-1 to open or high level at the plant to cause contact STP-1 to open. It should be noted that relay R2 has a number of contacts which will be called upon to perform various functions and that relay R2 will act as sort of a master switch for placing the station into service and for taking it out of service.

5. One of the relay R2 contacts will close when the relay is energized to energize solenoid valve "A" that connects the station rate setter output signal to rate controller No. 3 which in turn controls the position of the throttling gate allowing flow by gravity through the station at a controlled or regulated rate as required by the rate setter. Relay R2 contacts also partially enable circuits, that is they help to set up circuits, for solenoid valves 1A, 1B, 2A and 2B, on pumping units No. 1 and No. 2 respectively, should their operation become required.

6. The throttling gate, the flowmeter and the controller function as a rate controller under this condition to maintain the set-point flow rate as determined by the rate setter. The rate setter develops an output signal representing the desired rate of flow. Controller No. 3 receives this signal as its input and compares it with the feedback signal which represents actual flow. The output of controller No. 3 automatically varies as required to position the throttling gate to that position necessary to establish an actual flow signal equal to the set-point signal. Under this condition the actual flow is equal to the desired or set point flow. This is referred to as closed control loop with feedback.

7. If the Eight-Mile interceptor level falls to a level below 0.5 feet, relay R2 is de-energized, switching the controller input set-point signal line to exhaust (zero flow signal) causing the throttling gate to close to satisfy the zero flow signal. This, in effect, shuts down the station, after it normally has functioned by gravity flow for a period, without having entered a pumping stage.

8. If the desired (set-point) flow cannot be

maintained by gravity flow through the throttling gate, the gate obviously will have reached the fully open position, since it is positioned to try to satisfy controller No. 3. In this situation the diverted flow signal pressure will be less than the rate setter (set-point) signal pressure. By sensing the occurrence of this condition, the sensor can be used to initiate pumping. This sensor is differential pressure switch "A".

9. Differential pressure switch "A" shall be set to close a switch contact whenever the rate setter output signal exceeds the flow transmitter output signal by approximately 1.0 psi.

10. The switch contact of differential pressure switch "A" connected in series with a throttling gate limit switch, which closes only when the gate is fully open, energizes the time delay relay TD2. This time delay relay is to prevent starting of a pump unless this condition lasts for a reasonable period.

11. The time delay relay TD2 is adjustable from 0.2 to 3 minutes. If the throttling gate is open and the rate of flow through the regulating station is less than the desired (set-point) rate for a period equal to the time delay relay setting (one minute, for example), the time delay relay contact TD2 closes to pick up relay R3.

12. Relay contacts R3 close to complete the starting circuits of both pumps. It will not complete the starting circuit on the pump selected as "standby"; however, it will complete the starting circuit for the pump selected as "lead" provided there is sufficient suction level and that the second pumping unit is not running (a condition which could occur, for example, if it has been started under manual control). These conditions are imposed on the starter circuits by the series connection of contacts R1 and M2 in Pump No. 1 and contacts R1 and M1 in Pump No. 2.

13. To insure that sufficient water level on the influent to the regulating station exists for pumping, a level switch installed on the suction piping closes its switch contact at a measured water depth of 3-feet and above. This switch energizes time delay relay TD1.

14. The time delay relay TD1 is adjustable from 0.2 to 3 minutes. This relay, when energized closes its contact TD1 instantaneously but when de-energized the contact will delay opening for a period equal to the time delay relay setting (one minute, for example). Thus, loss of influent water level must be sustained for a reasonable

period to cause the time delay relay TD1 contact to open. This prevents stopping the pump upon a transient fall in water level during pump starting that is not sustained after pumping is commenced.

15. Time delay relay TD1 contact closes to pick up relay R1.

16. Relay R1 contacts energize each pump starting circuit, discharge valve control circuit, circuits to control the pump speed. These contacts are used in such a manner that, if a pump is running, loss of water level on the suction for a definite period de-energizes relay R1, causing the pump to reduce speed to minimum, the pump discharge valves to close, and the pump motor to stop.

17. Thus with sufficient suction water level available, closure of relay R3 contacts as stated above, starts the "lead" pump.

18. The pump starts at minimum speed. The set-point signal pressure to the pump speed controller is connected to exhaust (minimum speed signal) through solenoid "B". Note at this point that solenoid "B" is still de-energized.

19. When the motor starts, its motor starter holding coil (M1 or M2) is sealed by respective auxiliary (M1 or M2) starter contacts (M1 or M2) in series with a "Stop" push-button contact and a knee action limit switch on the pump discharge valve, thus eliminating any further effect of time delay relay TD2 and relay R3.

20. The closure of either pump motor starter auxiliary contact (M1 or M2) picks up solenoid "B", which switches the pneumatic set-point signal of the speed controllers (No. 1 and No. 2) from exhaust pressure (zero flow signal) to the rate setter signal pressure. This forces the pumping unit always to start from minimum speed.

21. The pump discharge valve is not to open until the developed pumping head exceeds any possible station discharge pressure by 5 psi. Differential pressure switches "1A" and "2A" on pumps No. 1 and No. 2, respectively, close their contacts as soon as the pump pressure exceeds the station discharge pressure by 5 psi.

22. Closure of the differential pressure switch contacts (1A or 2A) completes the control circuit through time delay relay TD5 contact, the automatic position of the pump "Manual-Off-Auto" switch, relay contact R2, relay contact R1, and the respective motor starter auxiliary switches (M1 or M2) to the

pump discharge valve (V1 or V2) control solenoid (1A or 2A) and relay (R5 or R6) on pump No. 1 or No.2, respectively, to initiate discharge valve opening.

23. When the pump discharge valve control solenoid (1A or 1B) becomes energized, it is immediately sealed by its associated relay (R5 or R6) contact so that the pump discharge valve continues to travel to the fully open position.

24. Also, during the starting and stopping of a pumping unit, the pump speed never is allowed to cause a differential pressure across the discharge valve in excess of 10 psi. To sense this condition, differential pressure switch (1B or 2B) across valve (V1 or V2) on pump No. 1 or No. 2; respectively, closes its contact when the developed pump pressure exceeds the station discharge pressure by 10 psi.

25. Closure of the differential pressure switch (1B or 2B) energizes solenoid (1B or 2B), respectively, which switches the pneumatic control signal to the positioner on the pump speed potentiometer to exhaust (zero speed) pressure, causing the positioner to start to operate in the direction of speed reduction. As speed is reduced to the point where the differential across the valve is within 10 psi, the solenoid (1B or 2B) is de-energized, thus connecting the controller output back to the positioner for continuation of speed control.

26. When the pump discharge valve is completely open, the variable speed pump together with the flowmeter and pneumatic controller associated with that pump then function as a closed control loop to regulate flow at the desired rate setting.

27. If the lead pump should fail to start and the Eight-Mile interceptor level rises to 2.0 feet, time delay relay TD3, which is adjustable from 0.2 to 3 minutes, will pick up relay R4 if this condition persists for a period equivalent to the relay time setting (one minute, for example).

28. Relay 4 contacts would then close to start the standby pump. The starting sequence of the standby pump would be as described above for starting of the lead pump. Note, however, that the standby pump will not start if the lead pump is running because of the interlocking starter auxiliary switches (M1 or M2).

29. As the hydraulic conditions vary, the variable speed pump may go to full speed if necessary to try to maintain the rate-set flow.

30. Also as the hydraulic conditions vary, the variable speed pump may reduce speed to a



minimum, yet the flow through the station might then exceed the rate-set (set-point) flow. When this condition develops, the station obviously could perform by gravity, without the pumping units. In this case the flow transmitter output signal pressure will exceed the rate setter output signal pressure. This condition is sensed by differential pressure switch "B" which closes its switch contact whenever the flow transmitter signal exceeds the rate setter signal by one psi.

31. Differential pressure switch "B" contact then closes to energize time delay relay TD4, which must be energized for a period (adjustable from 0.2 to 3 minutes) before its contact closes; hence, station flow greater than the required set-point flow for one minute, for example, will cause relay TD4 contact to close to pick up time delay relay TD5.

32. Time delay relay TD5 is one which has contacts that open immediately when energized and remain open after being de-energized for an adjustable period of 0.2 to 3 minutes.

33. The normally closed time delay relay TD5 contacts will then open to de-energize the control solenoid (1A or 2A) which causes the pump discharge valve (V1 or V2) to close. The purpose for the delay of the TD5 contacts is to allow sufficient time for the pump discharge valve to fully close. This relay should be set for a delay period slightly greater than the time it takes for the discharge valve to close.

34. As the discharge valve closes, the differential switch (1B or 2B) will prevent speed increase to occur to the point where the differential across the valve exceeds 10 psi, as explained previously, should the flow through the station fall below the set-point flow thus causing the pump speed controller to try to cause an increase of pump speed.

35. As the pump discharge valve closes the pump bypass check gate will commence to open to allow flow through the throttling gate by gravity.

36. As the pump discharge valve moves in its closing direction a knee action limit switch mounted on the valve will momentarily open the holding circuit of the motor starter as the discharge valve passes its 95 percent closed position, to stop the pump motor. The knee action switch on the valve is adjustable from 90 percent to 97 percent port closure. (The knee action limit switch on the discharge valve is normally closed and stays closed while the valve opens and during valve closure with the

exception of opening momentarily during the closing stroke at approximately the position of 5 percent valve port opening.

37. As soon as the motor starter is de-energized auxiliary motor starter contact (M1 or M2) opens to de-energize solenoid "B" which disconnects the rate setter signal from the pump speed controllers, causing the set-point signal pressure to the pump speed controllers (No. 1 and No. 2) to drop to exhaust pressure (zero speed signal pressure). This in turn causes the pump speed control potentiometers to be returned to zero speed position.

38. Controller No. 3 is then in control of the rate of flow through the throttling gate, acting again as a rate control system for gravity flow through the station.

39. The station then automatically returns to pumping if required or continually regulates flow through the throttling gate or, if the Eight-Mile interceptor water level falls to below 0.5 feet a contact in the Eight-Mile level receiver will open to break the seal-in circuit on relay R2, thus de-energizing relay R2.

40. When relay R2 is de-energized, the solenoid "A" in the station rate setter output signal line is de-energized, which switches the set-point signal line to the flow control system to exhaust, (or zero signal pressure) causing the throttling gate to close, thus shutting down the station.

41. Anytime during operation, if the Minneola Treatment Plant wet well level becomes too high, telemetering level receiver contact STP-1 opens to de-energize relay R2 to shut down the regulating station.

#### *Manual Control*

Manual control is provided mainly for checking the individual station components and for control whenever the Eight-Mile interceptor level telemetering receiver controller is out of service.

1. Under gravity flow conditions, the throttling gate may be throttled to any desired position and stopped and held in that position by means of the four-position "Automatic-Open-Stop-Close" manually operated pneumatic selector switch. In this case an attendant is required at the station to maintain the flow within the prescribed limits by watching the flowmeter. (Any time that the station is on automatic rate control this selector switch must be in the "Automatic" position.) This manual means of control is not necessary for local control of the station if pneumatic controller No. 3 is operative, since the controller

also can be switched to a manual loading station or set-point signal on the controller.

2. Under gravity flow conditions, if controller No. 3 is operative, the attendant may switch this controller from "Automatic" to "Manual" and adjust the controller output to obtain the desired flow.

3. If pumping is required, the attendant must switch the pump motor starter controls from "Automatic" to "Manual", and switch the pump speed control to a manually operated speed control potentiometer. (The speed control potentiometer should be set at its minimum speed position before starting the pump.)

4. The pumping unit is started by depressing the "Start" push-button. This closes the pump starter circuit and also starts the slip coupling to operate at the speed determined by the setting of the manually operated speed control potentiometer

5. The pump starter seals itself through its auxiliary contact (M1 or M2), the "Stop" push-button parallel with the valve limit switches, (V1 or V2), and the knee action switches (V1 or V2). (The purpose of parallel limit switches V1 or V2 is to permit stopping the pump motor if, for some reason, the discharge valve fails to open during the initial starting period.)

6. When the pump motor starts, the pump speed must be increased slowly until the pump discharge pressure is .5 psi above the station discharge pressure, to cause the pump discharge valve to commence to open. The differential pressure switch (1A or 2A) senses the 5 psi differential and energizes the pump discharge valve control solenoid (1A or 2A) and relay (R5 or R6) to seal the control solenoid circuit to drive the discharge valve fully open.

7. The attendant must raise the speed of the pumping unit gradually during the pump discharge valve opening cycle to prevent the development of greater than a 10 psi differential across the discharge valve.

8. If the pressure across the discharge valve exceeds 10 psi, the relay (R7 or R8) will pick up and sound an alarm. (This will notify the attendant to reduce or at least not to increase speed until the valve opens farther.)

9. When the discharge valve is fully open, the speed of the pumping unit is manually controlled to maintain the flow of the station at the required stage by watching the flowmeter and adjusting the manual speed control potentiometer accordingly.

10. The pumping unit is shut down by depressing the "Stop" push-button.

11. As the valve begins to close the speed should be reduced to maintain less than 5 psi differential across the valve.

12. When the valve is 97 percent closed, the pump motor will stop.

#### *Alarms and Instruments for*

#### *Future Operations Control Center.*

1. If relay R4, which actuates the standby pump, is energized and neither pump is running, the time delay relay TD6 is energized.

2. If relay R9, which indicates that the station flow exceeds set-point flow, is energized, the time delay relay TD6 is energized.

3. Time delay relay TD6, when energized for an adjustable period of 0.2 to 3 minutes, will close its contact to transmit an alarm tone via leased telephone line to the Operations Control Center.

4. The diverted flow rate is telemetered to the Operations Control Center. The recording receiver has an alarm contact which closes if the flow exceeds the contracted allowable limit.

5. As noted on the block diagram, it is planned that remote rate setting equipment will be installed in the future. Obviously when this is done a transfer switch "Local-Remote" should be installed to allow the use of either the original local rate setter or the remote rate setter.

The next step is to simplify the system as much as possible. This particular problem is an example of just how complex a system might become by seemingly relatively simple conditions existing when determining the design requirements. Limiting the working pressure across the discharge valves, for example, has introduced a number of controls, whereas, the selection of a different type of valve might have significantly simplified the control scheme. As the design progresses, it behooves the persons in each professional discipline involved to be aware of the complications they may be introducing by their particular design or selection of equipment and to attempt to simplify the control requirements.

Once the system has been simplified and established the scaling or calibration of the devices is necessary. This will involve the selection of the most suitable ranges for measurement with respect to control performance. In some cases separate metering for control is advisable, such as the measurement of water level. In this instance, one measurement is advisable for metering of zero to maximum level; another for level measurement of the narrow band over which control is to be exercised.

Another item that must be considered is use of "live" or "dead" zero output signals from instruments, as with time-impulse telemetering equipment. Arguments can be presented for both; but, for a particular application one will be more suitable than the other.

The designer must be concerned with accuracy, reliability, and maintenance requirements; must provide for clean, dry air for pneumatic systems as well as for voltage regulated within prescribed limits, for electrical circuits, together with over-voltage protective devices.

Although nothing has been mentioned herein regarding the telephone lines or communication facilities, it must be emphasized that regardless of the degree of excellence of the control system or equipment, the success or failure of the system will depend upon the quality and reliability of the communication facilities.

#### **7.4 Comments**

The customer must be extremely careful about

what is required from the control and instrument designer. Almost any system control problem can be solved but the cost of implementation and operation must not outweigh the benefits to the total system.

In the development of an Operation Control Center, the approach is somewhat similar to that mentioned herein for the design of a single station control scheme. Here the complete picture may be represented again in block diagram form with each block representing a certain controlled station, telephone exchange, and control center, with the interconnecting lines representing the communications channels. The degree of success will depend almost entirely upon the extent of understanding that each and every one has about the whole system and all of its component parts. This must include management, all of the professional services involved in design, equipment suppliers, contractor, and telephone and power utility personnel.

## SECTION 8

### ACKNOWLEDGEMENTS

The American Public Works Association is deeply indebted to the following persons and their organizations for the services they rendered to the APWA Research Foundation in carrying out this study for the 25 local governmental jurisdictions and the Federal Water Quality Administration who co-sponsored the study. Without their cooperation and assistance the study would not have been possible. The cooperation of the American Society of Civil Engineering (ASCE) and the Water Pollution Control Federation (WPCF) is acknowledged for their participation on the project Steering Committee.

#### Steering Committee

Arthur D. Caster (WPCF)	Walter A. Hurtley
William Dobbins (ASCE)	Peter F. Mattei, Chairman
George T. Gray	Ed Susong
Carmen Guarino (WPCF)	Harvey Wilke (ASCE)

#### Consultants

Dr. Morris M. Cohn, Consulting Engineer  
Ray Lawrence, Black & Veatch, Consulting Engineers  
M. D. R. Riddell, Greeley and Hansen, Consulting Engineers  
Morris H. Klegerman, Alexander Potter Associates, Consulting Engineers  
James J. Anderson, Watermation, Incorporated

#### Federal Water Quality Administration

Darwin R. Wright, Project Officer  
William A. Rosenkranz, Chief, Storm and Combined  
Sewer Pollution Control Branch, Division of Applied  
Science and Technology.

#### Manufacturers Advisory Panel

Vernon F. Brown	Badger Meter Manufacturing Co.
Peter A. Freeman	Bowles Fluidics Corporation
R. E. Gerhard	Allis-Chalmers Company
R. W. Henderson	Rodney Hunt Company
Karl E. Jasper	American Chain & Cable Co., Inc.
Louis F. Lemond	Coldwell-Wilcox Company
Charles Prange	Rockwell Manufacturing Co.
Milton Spiegel, Chairman	FMC Corporation
Jack D. Stickley	Honeywell, Inc.
E. P. Webb	Firestone Coated Fabrics Co.
Leon W. Weinberger	Zurn Industries, Inc.

## ACKNOWLEDGEMENTS (Continued)

### Advisory Committee

Vinton Bacon	The Metropolitan Sanitary District of Greater Chicago, Illinois
Donald Bee	City of Muncie, Indiana
Philip Blunck	Municipality of Metropolitan Seattle, Washington
C. A. Boeke	City of Middletown, Ohio
C. A. Boileau	City of Montreal, Quebec, Canada
Ron Bonar	City of Fort Wayne, Indiana
Richard J. Durgin	City of Alexandria, Virginia
Paul Ehrenfest	City of Cleveland, Ohio
John F. Flaherty	City of Boston, Massachusetts
George T. Gray	Allegheny County Sanitary Authority, Pittsburgh, Pennsylvania
Allison C. Hayes	Metropolitan District Commission, Boston, Massachusetts
Robert S. Hopson	City of Richmond, Virginia
Walter A. Hurtley	City of St. Paul, Minnesota
Roy L. Jackson	City of Kansas City, Missouri
Gene E. Jordan	City of Omaha, Nebraska
Robert E. Lawrence	Metropolitan Government of Nashville & Davidson County
O. H. Manuel	City of Charlottetown, P.E.I., Canada
Peter F. Mattei	Metropolitan St. Louis Sewer District, Missouri
Hugh McKinley	City of Eugene, Oregon
George J. Moorehead	Washington, District of Columbia
J. D. Near	City of Toronto, Ontario, Canada
Richard W. Respress	City of Atlanta, Georgia
Max N. Rhoads	City of Owensboro, Kentucky
Harry E. Rook	City of Syracuse, New York
Ben Sosowitz	The Metropolitan Sanitary District of Greater Chicago, Illinois
Ed Susong	City of Akron, Ohio